FIG 1-36

FIG 11-12

CLAIMS

1. System (100) for transporting electric energy in superconductivity conditions, comprising

- a superconducting cable (13) including superconducting material, and

- a cryogenic plant (1) for cooling said superconducting cable (13) below the critical temperature of said material, comprising:

a) a circuit (2) for circulating from and to the superconducting cable a first refrigerating fluid having a first predetermined temperature lower than the critical temperature of the superconducting material,

b) a refrigerating circuit (3) for cooling a second refrigerating fluid to a second predetermined temperature lower than the temperature of the first refrigerating fluid,

c) a heat exchange unit (31) for effecting a heat exchange between said first and second refrigerating fluids,

characterized in that said heat exchange unit (31) comprises a storage unit (4) of a third refrigerating fluid having a third predetermined temperature lower than the temperature of the first refrigerating fluid, said third refrigerating fluid being in heat exchange relationship with said first and second fluids.

2. System (100) according to claim 1, characterized in that said storage unit (4) has a predetermined volume adapted to contain a quantity of said third refrigerating fluid corresponding to the thermal consumption of said superconducting cable for at least two hours in the absence of a heat exchange with said second refrigerating fluid.

3. System (100) according to claim 1, characterized in that

the refrigerating circuit (3) for cooling the second refrigerating fluid comprises at least one refrigerating unit (17) provided with at least one heat exchanger (5) in heat exchange relationship with said storage unit (4).

4. System (100) according to claim 1, characterized in that the refrigerating circuit (3) for cooling the second refrigerating fluid comprises at least one refrigerating unit (17) in heat exchange relationship with the storage unit (4) and with said first fluid, said refrigerating unit (17) being positioned upstream of said superconducting cable (13) and the storage unit (4) being in parallel with said refrigerating unit (17).

5. System (100) according to anyone of the preceding claims, characterized in that said storage unit (4) comprises a storage tank (33) structurally independent from said refrigerating unit (17).

6. System (100) according to claim 1, characterized in that the heat exchange unit (31) further includes at least one heat exchanger (6) immersed in the third refrigerating fluid stored in said storage unit (4), said at least one heat exchanger (6) being provided with a fluid flowpath for the tube-side circulation of said first refrigerating fluid.

7. System (100) according to anyone of the preceding claims, characterized in that it comprises an auxiliary circuit (32) for maintaining the third refrigerating fluid at said predetermined temperature.

8. System (100) according to claim 7, characterized in that the auxiliary circuit (32) comprises at least one vacuum pump (7, 8) connected to said storage unit (4) by means of ducts (45, 46), at least one heat exchange unit (10) being interposed between said vacuum pump (7, 8) and said heat exchange unit (10).

9. System (100) according to claim 8, characterized in that the heat exchange unit (10) comprises at least one heat exchanger provided with a fluid flowpath for circulating a gas phase including vapors of said third refrigerating fluid.

10. System (100) according to claim 1 or 5, characterized in that it further comprises a container (12) for storing the third refrigerating fluid, said container (12) being selectively connected to the storage unit (4) of the heat exchange unit (31) by means of at least one duct (49).

11. System (100) according to claim 1, characterized in that the first refrigerating fluid is liquid nitrogen, and said first predetermined temperature is between 63 and 70K.

12. System (100) according to claim 1, characterized in that said second refrigerating fluid is gaseous helium having a pressure ranging between 1 and 20 bar, and said second predetermined temperature is between 40 and 55K.

13. System (100) according to claim 1, characterized in that said third refrigerating fluid is subcooled liquid nitrogen, and said third predetermined temperature is between 63 and 69K.

14. Cryogenic plant (1) for cooling a superconducting cable (13) including superconducting material below the critical temperature of said superconducting material, comprising:

a) a circuit (2) for circulating a first refrigerating fluid having a first predetermined temperature from and to the superconducting cable (13),

b) a refrigerating circuit (3) for cooling a second refrigerating fluid to a second predetermined temperature lower than the temperature of the first refrigerating fluid,

c) a heat exchange unit (31) for effecting a heat exchange

between said first and second refrigerating fluids,

characterized in that said heat exchange unit (31) is provided with a storage unit (4) of a third refrigerating fluid having a third predetermined temperature lower than the temperature of the first refrigerating fluid, said third refrigerating fluid being in heat exchange relationship with said first and second fluids.

15. Cryogenic plant (1) according to claim 14, characterized in that said storage unit (4) has a predetermined volume adapted to contain a quantity of said third refrigerating fluid at said predetermined temperature, corresponding to the thermal workload of said refrigerating circuit (3) for a time period of at least two hours in the absence of heat exchange with said second fluid.

16. Cryogenic plant (1) according to claim 15, characterized in that said storage unit (4) has a volume corresponding to the thermal workload of said refrigerating circuit (3) for a time period of at least twelve hours in the absence of heat exchange with said second fluid.

17. Cryogenic plant (1) according to claim 14, characterized in that said storage unit has a volume of at least 2000 liters.

18. Cryogenic plant (1) according to claim 14, characterized in that said storage unit has a volume of at least 12000 liters.

19. A method for cooling in continuous a superconducting cable (14) including superconducting material below the critical temperature of said superconducting material, comprising the steps of:

- circulating a first refrigerating fluid from and to the superconducting cable (13),

- cooling the first refrigerating fluid to a first predetermined temperature by means of a second refrigerating fluid having a second predetermined temperature lower than the temperature of the first refrigerating fluid,

which is characterized in that the cooling step of the first refrigerating fluid is effected by means of the further steps of:

- providing a cryogenic bath of a third refrigerating fluid in a storage area (4),

- cooling the third refrigerating fluid to a third predetermined temperature lower than the temperature of the first refrigerating fluid by means of said second fluid,

- cooling the first refrigerating fluid by means of the third refrigerating fluid stored in the cryogenic bath.

20. Method according to claim 19, characterized in that the third refrigerating fluid is cooled to an intermediate temperature between the temperatures of the first and second refrigerating fluids.

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